

NANOFAB TOOL USAGE RATES
Effective 1/1/13

Category	Tool	Description	Location	Tool Usage	Tool Usage
				Full Rate	Reduced Rate
				\$/Hour	\$/Hour
Chemical Vapor Deposition	Oxford FlexALRPT Atomic Layer Deposition	Both Thermal and Plasma ALD Processes of SiO ₂ , Al ₂ O ₃ , TiO ₂ , HfO ₂ , up to 200mm substrates	C	105	53
	Unaxis 790 Plasma Enhanced CVD	Low temperature deposition of oxide, nitride and amorphous silicon thin films, up to 200mm substrates	C	138	69
CMOS	Unaxis Shuttleline ICP Etcher	Chlorine etching of silicon for ultra-clean applications	C	178	89
	Tystar Wet Oxidation Furnace	Pyrogenic Oxidation of silicon up to 1150 °C	C	145	73
	Tystar Dry Oxidation Furnace	Dry Oxidation of Si up to 1150 °C	C	145	73
	Tystar Sinter Furnace	10% Forming gas and nitrogen anneal	C	81	41
	Tystar Doping Furnace	Phosphorus and Boron doping of silicon	C	81	41
	Tystar Polysilicon Low Pressure CVD	Doped and Undoped polysilicon depositions	C	131	66
	Tystar Silicon Nitride Low Pressure CVD	Low stress and stoichiometric silicon nitride deposition	C	129	65
	Tystar Low Temperature Oxide CVD	Low temperature oxide deposition	C	142	71
Dry Etching	Unaxis Shuttleline Deep Si Etcher	"Bosch" Process Capability 1 to 15 um per minute high selectivity (>100:1 SiO ₂ , >40:1 Photoresist)	C	132	66
	Oxford PlasmaLab 100	Chlorine or Fluorine Etching especially suited to III-V, metals, and anisotropic silicon etching, cryogenic and high temperature etch capability -150 to 400 °C, up to 200mm wafer capable	C	130	65
	Unaxis 790 RIE	General Fluorine Etching of dielectrics and metals	C	113	57
	XeF ₂ Silicon Etcher	High rate silicon removal for mems release etch	C	118	59
	Microwave Asher	Polymer Removal and Surface Clean	C	76	38
	4Wave Ion Mill	Argon ion milling of metals and dielectrics (150mm wafer maximum), large 22 cm ion source provides < 1% non-uniformity, low base pressure, fast cycle, SIMS endpoint detection, reactive ion beam etch capable with SF ₆ , CF ₄ , CHF ₃ , and O ₂ gases installed	C	121	61
General Use Furnaces	Tystar Dry Ox Furnace	Dry Oxidation of Si up to 1200 °C	C	75	38
	Tystar Wet Ox Furnace	Pyrogenic Oxidation of Si up to 1150 °C	C	78	39
	Tystar Sinter Furnace	10% Forming gas and nitrogen anneal	C	80	40
	Tystar Anneal Furnace	Nitrogen and Oxygen anneal up to 1100 °C	C	75	38
	Modular Process Rapid Thermal Annealer	Rapid thermal processing up to 1200 °C in N ₂ , O ₂ , Ar, or 10% Forming Gas, up to 6" wafers	C	153	77
Imaging and Analysis	Zeiss Ultra 60 Field Emission SEM	1.5 nm resolution, 1 to 30 keV, Oxford EDS for detection and mapping of elements Be and heavier, in lens and Everhart Thornley secondary detectors, and in lens energy selective and four quad backscatter detectors, up to 150 mm wafers	C	125	63
	FEI Titan Analytical TEM	Information Limit 0.10nm, STEM resolution 0.14nm, 80 to 300kV, Gatan Orius 2kx2k digital camera, Fischione HAADF STEM detector, Gatan GIF for EELS and EFTEM, EDAX EDS for elemental detection and mapping. Tomography acquisition, reconstruction, and analysis software	E	345	173
	Veeco Dimension 3100 Atomic Force Microscope	Contact, Tapping, and Phase imaging modes, up to 200 mm substrates, electrostatic force microscopy, magnetic force microscopy.	C	130	65
Focused Ion Beams	FEI Helios 650 Dual Beam FIB/SEM	SEM Imaging resolution <1nm from 1 to 30kV, FIB resolution 2.5nm at 30kV, STEM detector, Integrated Oxford EDS for detection and mapping of elements Be and heavier, beam deceleration for 50 V effective landing voltage, Kleindiek In-situ probe system for nanopositioning and electrical measurement, gas injection system supports Pt, Au, C, insulator deposition and selective carbon and insulator enhanced etch, slice and view 3D reconstruction, TEM lamella prep, circuit editing, wafers up to 150 mm	E	325	163
	Zeiss NVision40 Dual Beam FIB/SEM	SEM Imaging resolution 1.1 nm at 20 kV, FIB resolution 4 nm at 30kV, gas injection system supports Pt, W, C and insulator deposition, slice and view 3D reconstruction, TEM lamella prep, circuit editing, load lock for fast sample change, wafers up to 100 mm.	E	254	127
Lithography	JEOL E-beam JBX 6300-FS	2 nm spot size, 12 MHz write speed, 200 mm loadable	E	605	303
	Vistec E-beam VB300	4 nm spot size, 50 MHz write speed, 1.2 mm scan field, 300 mm loadable	C	1041	521
	Raith Elphy E-beam	Ion Beam 4nm spot size at 30 kV or Electron Beam 1 nm spot size at 20kV, 100 mm loadable, integrated with Zeiss N-Vision40 FIB/SEM	E	125	63
	ASML Stepper PAS 5500/275	High throughput 5x projection I-Line lithography; < 300nm resolution; 3D backside alignment, 200 mm loadable, 22 x 27 mm field size	C	195	98
	Suss MA6 Contact Aligner	I or G line contact exposure with front and back side alignment, 1 um resolution, up to 150 mm substrate	C	57	29
	Suss MA8 Contact Aligner	I or G line contact exposure, 1 um resolution, up to 200 mm substrate	C	57	29
	Heidelberg DWL-66FS Laser Writer	<1 um resolution, greyscale writing modes, backside alignment capable, direct substrate write or mask exposure	C	133	67
	Nanonex NX-2000 Nano-imprinter	UV and Thermal Large Area Imprint, Features down to 10 nm	C	139	70

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Category	Tool	Description	Location	Tool Usage Full Rate	Tool Usage Reduced Rate
				\$/Hour	\$/Hour
Packaging	Disco 341 Dicing Saw	Wafer dicing (8" wafer maximum)	E	95	48
	K&S 4526 Wire Bonder	Manual wire bonder for electrical interconnect	E	122	61
Physical Vapor Deposition	Denton Infinity 22	Thermal and E-beam evaporation of over 30 metal and dielectric sources provided, co-evaporation available, ion assist, ion wafer clean, fast cycle under 30 minute pumpdown	C	128	64
	Denton Discovery 550	RF and DC sputtering of over 30 metal and dielectric targets provided, magnetically enhanced gun, up to 600 W., heated stage to 350 °C, co-sputtering available, wafer pre-sputter, Oxygen and Nitrogen available for reactive sputtering	C	128	64
	Speciality Coatings PDC-2012 Parylene Deposition	Parylene N or C only, thickness to tens of microns	C	86	43
Speciality Tools	Suss Microtec SB6e Wafer Bonder	Thermal, pressure and anodic bonding with vacuum or over-pressure condition	E	152	76
	Tousimis Critical Point Dryer	Drying of high aspect ratio fragile structures on pieces to 6" wafers	C	104	52
	Bruker-TMT Chemical Mechanical Planarization	Chemical Mechanical Polisher (4" wafer maximum)	E	97	49
Access	Cleanroom Occupancy Rate	Clean room entrance fee includes gowning, most wet chemistry, and metrology including: Toho Tech FLX-2320 Laser Film Stress Measurement Firsttenangstroms FTA32 Contact Angle Goniometer Woollam XLS-100 Spectroscopic Ellipsometer Nanometrics Nanospec reflectometer Bruker Dektak XT surface profilometer Jandel RM2 four point probe Microscopic and Macroscopic Optical imaging and inspection Hitachi TM-1000 small sample SEM up to 10kx Keithley 4200 Parametric with capacitance, pulse, and high current	-	64	32
	Processing Services	NanoFab Engineers can perform process development and run complex processes on your behalf in the NanoFab including mask layout with or without you present	-	119	119
	Processing Services	NanoFab Process Technicians can run standard process on your behalf with or without you present	-	70	70

Note: Location 'C' indicates that the tool is located inside of the cleanroom and incurs the clean room occupancy fee in addition to the tool rate.
Location 'E' indicates that the tool is located outside of the cleanroom.

NANOFAB TOOL TRAINING RATES Effective 1/1/13

Category	Tool	Typical Training Time	Individual Training Rate	Group Training Rate
		Hours	\$/Hour	\$/Hour
Chemical Vapor Deposition	Oxford FlexALRPT Atomic Layer Deposition	2	172	86
	Unaxis 790 Plasma Enhanced CVD	1	188	94
CMOS*	Unaxis Shuttleline ICP Etcher	2	208	104
	Tystar Wet Oxidation Furnace	1	192	96
	Tystar Dry Oxidation Furnace	1	192	96
	Tystar Sinter Furnace	1	160	80
	Tystar Doping Furnace	1	160	80
	Tystar Polysilicon Low Pressure CVD	1.5	185	93
	Tystar Silicon Nitride Low Pressure CVD	1.5	184	92
	Tystar Low Temperature Oxide CVD	1.5	190	95
Dry Etching	Unaxis Shuttleline Deep Si Etcher	2	185	93
	Oxford PlasmaLab 100	2	184	92
	Unaxis 790 RIE	2	176	88
	XeF2 Silicon Etcher	1	178	89
	Microwave Asher	0.5	157	79
	4Wave Ion Mill	2	180	90
General Use Furnaces	Tystar Dry Ox Furnace	1	157	79
	Tystar Wet Ox Furnace	1	158	79
	Tystar Sinter Furnace	1	159	80
	Tystar Anneal Furnace	1	157	79
	Modular Process Rapid Thermal Annealer	1	196	98
Imaging and Analysis	Zeiss Ultra 60 Field Emission SEM	4	182	91
	FEI Titan Analytical TEM	20	292	146
	Veeco Dimension 3100 Atomic Force Microscope	2	184	92
Focused Ion Beams	FEI Helios 650 Dual Beam FIB/SEM	5	282	141
	Zeiss NVision40 Dual Beam FIB/SEM	5	246	123
Lithography	JEOL E-beam JBX 6300-FS	6	422	211
	Vistec E-beam VB300	Only NanoFab Staff Operate the Vistec		
	Raith Elphy E-beam	4	182	91
	ASML Stepper PAS 5500/275	6	217	109
	Suss MA6 Contact Aligner	4	148	74
	Suss MA8 Contact Aligner	4	148	74
	Heidelberg DWL-66FS Laser Writer	4	186	93
Nanonex NX-2000 Nano-imprinter	3	189	95	
Packaging	Disco 341 Dicing Saw	3	167	84
	K&S 4526 Wire Bonder	1	180	90
Physical Vapor Deposition	Denton Infinity 22	2	183	92
	Denton Discovery 550	2	183	92
	Speciality Coatings PDC-2012 Parylene Deposition	1	162	81
Speciality Tools	Suss Microtec SB6e Wafer Bonder	4	195	98
	Tousimis Critical Point Dryer	1	171	86
	Bruker-TMT Chemical Mechanical Planarization	3	168	84
All Other Tools	Tools without hourly tool charges	Varies	119	59.5

Typical training times cover general tool operation and can vary depending on previous experience and aptitude. Application specific training beyond general tool usage will require additional training time and should be discussed with process engineer prior to training.

* All CMOS tools require a one time 2 hour NanoFab CMOS protocol training prior to CMOS tool training.